AIRCELL RESPONSE TO FCC QUESTIONS

Air-to-Ground Proceeding
WT Docket No. 03-103

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Introduction

AirCell Inc. ("AirCell") is pleased to provide its analysis of the air-to-ground (ATG) licensing approaches under consideration by the Commission staff, and to respond to several specific ATG questions. For the past three years, we have dedicated substantial time and resources to develop state-of-the-art, 3G, broadband services for both the commercial airline and general aviation markets. We have filed and received a number of patents for our ATG technology and have served as a leader in the effort to find appropriate methodologies to permit the use of personal cell phones and other mobile devices in flight.

Out of our history and experience, including our extensive ongoing discussions and contacts with wireless service providers, aviation companies and airlines, we can with great confidence say that the following *fundamentals* must be in place before vigorous, successful air-to-ground communications will take hold on commercial airlines:

1) The consumer, the *passenger*, wants and must be able to use his or her personal cell phone, PDA, laptop or other mobile device in the air *in just the same manner as on the ground*.

2) Both passengers and airlines want broadband. Period. There is no market opportunity for narrowband service.

3) *The ATG broadband network must be cost-effective* – in terms of equipment, installation and operating costs to the airlines, and in terms of pricing for the end-user. Although satellite services offer a broad range of ATG services at vastly varying costs, none of them are suited to providing the cost-effective broadband solution required by U.S. airlines. Low-cost, terrestrially-based ATG broadband services are the only logical solution to serving the vast majority of U.S.-based airline aircraft; otherwise, why would Boeing, a provider of satellite-based services to commercial airlines be advocating a competitive terrestrial ATG service?

4) *Multiple service providers are needed in the ATG band* to avoid the artificially high prices that will be possible because of the significant cost advantage of terrestrial-based systems over satellite-based operators. Even though it is unlikely that more than one ATG service provider will be installed on a single airplane, competition is still necessary for airlines to insist on affordable pricing for passengers and the airlines themselves.

AirCell believes that it is practical and advantageous to allow a minimum of two - and up to four - service providers to share the ATG spectrum to provide competitive broadband ATG service to the airlines and their passengers. Moreover, there is no material technological difference between use of the ATG band by two licensees or four licensees – a view supported by Boeing. We believe our four-licensee proposal deserves the strongest consideration by the Commission as this would permit maximum competition in ATG services, while providing the same broadband bandwidth, data rates, capacity and user experience as an exclusive license approach.

On the other hand, AirCell sharply disagrees with the "exclusive" spectrum proposal for division of the ATG band into one 2.5 MHz "A Block" and one 1.5 MHz "B Block." AirCell has studied this proposal and concluded that it would create a viable broadband system in the A Block only, and that the weaker B Block would be virtually useless as a platform from which to offer competitive ATG service. Our analysis is as follows:

1. There is No Cost-Effective Technology to Support Broadband in the B Block. The B Block will not support any form of economically feasible broadband service due to the lack of existence of a readily available broadband solution with 0.75 MHz (or narrower) channels. Developing a custom broadband system for the B Block would be very expensive and would not be an economically viable solution for the ATG band. Even if a B Block licensee were to invest time and expense in an attempt to develop a custom solution, this would provide the A Block licensee with an unfair head start, which it could use to gain a significant foothold in the market by signing-up airlines eager to offer broadband service to their passengers. Given this situation, the most likely result is that narrowband would remain the only choice for the B Block. Thus, a separate narrowband block would be underutilized and spectrally inefficient, much like the current ATG band, since there is insufficient market opportunity for such services. Indeed, virtually all commenters in this proceeding are in agreement on the market demand for broadband, not narrowband, services.

It may be argued that TDMA off-the-shelf cellular systems (such as GSM-based solutions) may provide a solution for the B Block, but this will not be true for the following reasons:

(i) GSM systems use 200 kHz channels; 2 x 750 kHz bandwidth is inadequate to provide enough channels to meet GSM frequency reuse requirements.
(ii) Experiments performed by AirCell show that GSM and other similar TDMA solutions cannot be operated at commercial airline speeds with the resulting Doppler shift, making them unsuitable for the ATG band.
(iii) A guard band is required between systems operating broadband and narrowband technologies due to high power spectral density of the narrowband systems. Introducing a guard band under the proposed A/B exclusive licensing approach will further limit the value of the B Block.

2. Potential for One Company to Obtain a Monopoly. The exclusive spectrum proposal would not provide competition in a meaningful way. It is likely that Verizon Airfone (or another potential service provider) would bid for and could win the auction for the A Block. The probability of low interest in the less desirable B Block makes it likely that either this block would go unlicensed, or that the winning bidder for the A Block would make a lower bid for the B Block to use it to augment its A Block services and create a permanent ATG monopoly.

3. Underutilization of the Spectrum. The exclusive licensing approach being considered underutilizes the available spectrum. AirCell has clearly demonstrated that the underlying ATG spectrum can be utilized in a much more efficient manner, whereby two or four service providers can provide broadband ATG services without causing interference to each other. Thus, the exclusive spectrum approach would be only one-quarter as spectrally efficient as AirCell's proposed approach.

4. Relative Lack of Broadband Flexibility. The exclusive spectrum proposal, with fixed 2.5/1.5 MHz assignments, provides no practical flexibility in the selection of broadband RF technologies other than those that require 1.25 MHz (or less). AirCell more flexible approach will permit the introduction of competitive technologies developed in the future, which may require greater bandwidth (and which can co-exist with technologies that are already available.)

Conclusion: Based on the foregoing, AirCell does not see any basis which would justify our seeking to acquire license rights to the proposed narrowband B Block. We are skeptical of any claim that the B Block would support a robust, competitive broadband system. With the likely failure of the B Block to support broadband, FCC adoption of the A/B Block proposal would result in creation of a monopoly in the A Block – a result that would be counter to the public interest in competitive, low cost and high quality telecom services.

Commission Staff Questions and AirCell Responses:

Below are our responses to the specific questions posed to us by Commission staff on the best methodologies for re-structuring the ATG band to provide broadband ATG service to the airlines and their passengers.

Q1) What is the data rate to the seat under the AirCell proposal for two or four licensees, and how does that compare to the FCC's exclusive spectrum proposal?

A1) AirCell's research shows that CDMA 2000 1xEVDO is the most appropriate technology for broadband in the ATG environment. Criteria for the optimum ATG link includes:

- High data rates on forward and reverse links to provide broadband data service to passengers, with low enough latency to support voice services;

- Contiguous cell-to-cell frequency reuse (N=1), in order to accommodate broadband channels within the relatively limited ATG spectrum;
- Capacity to resist relatively large Doppler shifts in large coverage area cells found in the ATG environment.

1xEVDO Rev A is the most recent version of EVDO, offering 3.1 Mbps throughput on the forward link and 1.8 Mbps on the reverse link, with low data latency support. This represents a significant improvement over the earlier version (rev 0), which had been used for AirCell's earlier performance analysis.

See http://www.qualcomm.com/technology/1xev-do/enhancements.html for additional details regarding EVDO Rev A.

AirCell has confirmed through field tests that EVDO can provide service even in the face of Doppler shifts created by aircraft speeds, and Rev A can support cell radii of up to 250 km/155 mi. See http://www.cdmatech.com/solutions/pdf/csm6800.pdf. For these reasons, AirCell regards CDMA 1xEVDO Rev A as the primary candidate for ATG broadband services.

Passengers on board the aircraft using data services are expected to use their laptops (or PDAs) to access their email or browse the web. There have been a number of research papers presented to model the Internet traffic (such as Poisson traffic model, self-similar network traffic and other variants). The data traffic flow is generated by many applications such as HTTP, FTP, SMTP or Telnet. Researchers suggest that it is important to study aggregate traffic by application since the packet processes for different applications are different. While it is out of the scope of this paper to present the nuances related to this topic, one can summarize the effect by saying that the ATG user experience will be similar to that encountered in an office, where perhaps 40 people may share a T-1 line for broadband access. Due to the intermittent, bursty nature of their data traffic, they will generally each receive relatively unrestricted access to the broadband facility (which in the case of an ATG link is up to 3.1 Mbps and 1.8 Mbps on forward and reverse links respectively).

As the number of users grows, or their data access intensity increases, passengers will begin to experience some impact from the overall use of the network. However, in the wireless links such as an ATG link, one can engineer the network to some extent so that a certain level of user experience is maintained by spreading the overall usage/traffic among many cells (cell splitting).

Table 1 below provides a comparison of the user experience, data rates, capacity, etc. between these different licensing schemes. The user experience and data rates are compared to a typical broadband connection (Wi-Fi hot-spot with a T1 access into the Internet) and the current ATG service provided in the entire 4 MHz ATG spectrum by Airfone.

Table 1 - Comparison of Broadband User Experience and Data Rates

Variable	Exclusive spectrum proposal		Two-licensee proposal	Four-licensee proposal	Verizon Airfone (existing)	Typical Wi-Fi hotspot
Bandwidth per licensee	2.5 MHz A Band (broadband monopoly)	1.5 MHz B Band	2.5 MHz	2.5 MHz	4.0 MHz (monopoly)	N/A Unlicensed bands
Overall user experience	"Hot-spot" like Broadband		"Hot-spot" like Broadband	"Hot-spot" like Broadband	Low speed, limited dial-up	Broadband
Connectivity experience[1]	Broadband connection	Narrowband connection	Broadband connection	Broadband connection	Narrowband, low-speed	Broadband connection
Connection setup	Always On	Possibly always on	Always On	Always On	Dial up	Always On
Link / suitability for Web browsing	Asymmetric (higher speed forward link); Ideal for real-time web browsing	Unsuitable	Asymmetric (higher speed forward link); Ideal for real-time web browsing	Asymmetric (higher speed forward link); Ideal for real-time web browsing	Low speed symmetric; non-real –time, limited web browsing	Asymmetric (higher speed forward link); Ideal for real-time web browsing
Applications (standard internet services)	Web Browsing, E-mail, FTP, ecommerce, gaming	Limited	Web Browsing, E-mail, FTP, ecommerce, gaming	Web Browsing, E-mail, FTP, ecommerce, gaming	Extremely limited and controlled by service provider	Web Browsing, E-mail, FTP, ecommerce, gaming

Variable	Exclusive spectrum proposal		Two-licensee proposal	Four-licensee proposal	Verizon Airfone (existing)	Typical Wi-Fi hotspot
Peak data rate to aircraft - forward and (reverse) links[1,2]	3.1 Mbps (1.8 Mbps)	Unknown	3.1 Mbps (1.8 Mbps)	3.1 Mbps (1.8 Mbps)	9.6 Kbps (9.6 Kbps) (max of 38.4 kbps possible)	1.54 Mbps (1.54 Mbps) (assume T1 access)
Peak data rate to seat/user – forward and (reverse) links[1,2]	3.1 Mbps (1.8 Mbps)	Unknown	3.1 Mbps (1.8 Mbps)	3.1 Mbps (1.8 Mbps)	9.6 Kbps (est.) (9.6 Kbps (est.))	1.54 Mbps (1.54 Mbps) (assume T1 access)

Table Notes

1. Peak data rates to each user/seat are approximately the same as the peak data rate to the aircraft (access pipe), because of the bursty nature of data traffic. Peak data rates are based on EvDO rev. A technology.

2. Simulation done using 10 and 15 users per aircraft, with ten and three aircrafts per cell respectively (under three different licensing schemes as above), and with forward (download) and reverse (upload) passenger call-for-data activity rates of 20% and 10% respectively.

Since AirCell's two-licensee and four-licensee proposals allow for multiple independent broadband systems (2.5 MHz bandwidth per system), **multiple systems will provide the same broadband bandwidth, data rates, capacity and user experience as a single-licensee proposal, with no difference in data rates to the seat**.

Q2) Is it possible for the incumbent to continue to operate beneath the overlapping licenses under either of AirCell's approaches?

A2) AirCell has addressed this issue in previous documents submitted to the FCC by providing a migration plan for both its proposals. AirCell believes it is not possible for the incumbent to operate in the entire 4 MHz band and co-exist with multiple broadband licensees, because it would produce an unacceptable level of interference. The incumbent system will create severe interference upon the broadband systems due to near-far problems that are further exacerbated by the higher transmit powers of the incumbent systems.

In both AirCell proposals, a migration plan is possible wherein the incumbent migrates to 1.2 MHz (2 x 0.60 MHz) bands at one end of the ATG spectrum blocks, without causing significant interference to, or receiving significant interference from, the primary systems. If the incumbent migrates according to the AirCell's migration plan, the incumbent can continue to operate in 1.5 MHz spectrum at the ends of the two partitions of the ATG band. However providing for guardband, only 1.2 MHz (2 x 0.60 MHz) of spectrum will be usable for narrowband technology by the incumbent. In such a scenario, the cost of this co-existence is a short-term reduction in the capacity of the primary systems and equipment costs would remain virtually unaffected. Finally, the incumbent network migration costs will be the same under AirCell's multiple license migration plan as under a migration plan required to clear an exclusive A Block.

Q3) What rules need to be established to accommodate multiple ATG providers in the 4 MHz ATG spectrum?

A3) The rules needed to coordinate between two or four licensees are detailed below. As noted, there is only one additional rule to accommodate four licensees instead of two.

For the two-service provider licensing plan, the following rules would apply:

- Max. aircraft EIRP of 200 mW radiated towards any other system ground station or aircraft.
- Max. ground station EIRP of 200 W radiated towards any other system ground station or aircraft.
- If signals not occupying 1.25 MHz, then equivalent maximum spectral power density must be observed.
- Base station isolation requirements not required for "cross-country" base stations (*i.e.*, those base stations not near major airports).

- In the vicinity of major airports, rules would limit base-base cross-duplex interference and provide an opportunity for multiple service providers to provide low-altitude services:

    - Maximum EIRP of 200 mW to horizon +/- 2 degrees (met using uptilt antennas).
    - Minimum intra-system site spacing requirement.
    - Expectation that carriers will coordinate to achieve acceptable inter-system isolation.

For a four-service provider scenario, cross polarization isolation must be protected, and the following additional rule would be required:

- Cross polarization discrimination preserved by i) requiring ground station antenna alignment within 1 degree, and ii) reducing aircraft transmit power to compensate dB-for-dB for cross polarization reduction below 12 dB. Polarization and cross-duplexing will required as detailed in the table below:

System	Pol.	Initial Channels (MHz)		Final Channels (MHz)	
		Ground	Air	Ground	Air
Existing	V	849.00 - 849.60	894.00 - 894.60	-	-
System 1	V	894.75 - 896.00	849.75 - 851.00	894.00 - 895.25	849.00 - 850.25
System 2	**V**	**849.75 - 851.00**	**894.75 - 896.00**	**849.75 - 851.00**	**894.75 - 896.00**
System 3	H	894.00 - 895.25	849.00 - 850.25	894.75 - 896.00	849.75 - 851.00
System 4	**H**	**849.00 - 850.25**	**894.00 - 895.25**	**849.00 - 850.25**	**894.00 - 895.25**

Ground station separation: The locations of base stations of different service providers have to be selected such that they do not interfere with each other. Close spacing of ground stations may be achieved by direct coordination and engineering of selected sites between carriers.

Limits on modulation: For either the two or four service provider licensing scenario, licensees will be free to implement any technology, subject to the rules set forth above.

Directional antennas on aircraft: Directional antennas on aircraft are not required for either AirCell's two or four service provider licensing scenarios.

Tracking software on the ground or on aircraft: None of the three alternatives require tracking software.

Q4) What is the difference in the equipment/network costs between AirCell's proposed multiple systems and the A/B Block exclusive spectrum proposal?

A4) There is no significant difference in cost between implementation of the AirCell multiple service provider proposal and the A/B Block exclusive spectrum proposal. AirCell envisions that all broadband service providers (those licensed under any of the AirCell scenarios, or an A Block licensee under the exclusive spectrum scenario) will utilize commercially available base station equipment, perhaps with minor design modifications and/or additional "bolt-on" filters.

However, the availability and cost of ground and aircraft equipment to be used by a B Block service provider is far less certain. GSM systems are not compatible with a 2 x 0.75 MHz block. IS-136 systems represent technology that is being broadly displaced by 2.5G and 3G technologies, and may present future product availability issues as well as shorter-term capacity/quality challenges. If a technology must be custom-developed for the B Block, both the service availability and the economics of the resulting business are likely to be uncompetitive with the A Block broadband service.

Q5) What are the impacts of these licensing schemes on future growth and technology evolution?

A5) As mentioned earlier, AirCell's two-licensee and four-licensee proposals essentially provide two and four independent broadband systems respectively (2.5 MHz bandwidth per system). Each licensee has complete freedom to choose any version of broadband technology (close to 1.25 MHz bandwidth). Since the systems are isolated, the limiting factor on technology evolution, capacity growth, and data rates are the same as what would exist if there were to be only one licensee using the same broadband technology. For example, the number of users in a sector or cell, data rate demand per user, cell or sector size, other cell interference, etc. will play a key role in determining the limits on capacity growth and average and peak data rates. These factors will be the same whether or not there are multiple licensees or just one licensee. The effects on average data rates due to inter-system interference (because of multiple licensees) is minimal (less than 2% reduction from a single licensee scenario) compared to the factors listed above.

Under AirCell's multiple licensing proposal, just like in a terrestrial system, certain limits were assumed in the simulation and suggested as rules only to prevent rogue behaviors and situations where higher transmit powers can only cause more damage than benefit. These rules exist in terrestrial systems as well and they are certainly not indicative of limitations on capabilities of terrestrial systems. They reflect the fact that the industry believes there are not significantly higher benefits to be achieved by relaxing these rules while there could be severe disadvantages. Similarly, AirCell's suggested rules reflect and foster best practices and behavior from service providers, while there is flexibility to change them if benefits can be realized from the changes.

Note: Arbitrary calculations of the need for higher transmit powers (such as one done by Telcordia) are full of misleading assumptions and conclusions. One of the analyses performed by Telcordia shows extra transmit power required (and hence signal to interference and noise ratio (SINR) achieved) to achieve X Kbps compared to 48 Kbps (for different values of X). The assumption that AirCell can support only 48 Kbps, and further, the implied assumption that a single licensee scheme can support more than 48 Kbps (X Kbps) in the same situation is totally false. As noted above, given a technology and certain traffic demand/distribution, it might be impossible under any licensee scenario to provide X Kbps average data rate to a user. With the isolation provided by AirCell's proposals, the only limitation on data rates is what is achievable by then state-of-the-art technology.

The isolation mechanisms also offer complete flexibility for each licensee to adopt and evolve to any broadband technology of their choice at any time.

In addition, AirCell's proposals allow carriers to develop additional capacity using techniques commonly employed by terrestrial mobile service carriers - adding cells and/or evolving to more sophisticated standards (*e.g.*, EvDO rev. 0, EvDO rev. A, etc). In a given network, traffic and customer growth are typically addressed by adding or splitting cells. This is an engineering and business decision that takes into account technical issues such as capacity or data rate increase obtained by adding cells, changes in system settings such as transmit power to reduce inter-cell interference, cell location to maximize capacity increase, etc. Business issues such as customer experience, customer expectations, and return on investment play a significant role. It should be noted that, in any system, there is a diminishing marginal increase in capacity from cell splitting due to intra-system interference. This diminishing capacity increase effect is further amplified when the economics/business factors are taken into account, *i.e.*, one cannot and will not choose to add cells to get increased capacity beyond a certain point.

AirCell's proposals offers a superior solution, compared to a single licensee scheme, to address future growth in ATG traffic because:

1. Multiple service providers (competition) cause sharing of the total market demand, thereby enabling service providers to operate at the profitable/optimum points of cell capacity.
2. Customers benefit from competition among service providers to offer the best user experience (this serves as the balancing factor for "profit-gouging" in the A/B Block spectrum plan).
3. As explained above, the multiple systems scenario provides better technical and business efficiency (*i.e.*, X cells operated by single service provider in a given area will have less capacity than X/2 cells operated by 2 service providers that have independent, isolated systems)

Q6) Can cell phones be used during flight without interfering with terrestrial systems?

A6) Yes. AirCell supports removal of restrictions regarding the use of cell phones while airborne so long as they are under the control of an onboard system that meets acceptable levels of out-of-aircraft emissions. Use of cell phones in "native" mode, without such an onboard control system should not be permitted. Some additional research and experimentation is required in order to establish an acceptable level of emissions outside the aircraft, while not interrupting or degrading terrestrial wireless systems. AirCell will make specific recommendations on this matter once our experiments on this subject have been completed.

Q7) Can a service provider offer coverage below 10,000 feet (all the way to the terminal) under AirCell's proposals?

A7) Yes. Under AirCell's proposal, all service providers can offer coverage below 10,000 feet, though we expect system use under 10,000 feet to be primarily for the airlines given the FAA requirement to stow passenger electronic devices below 10,000 feet. As different aircraft with different service providers get closer to each other at or near the ground, inter-system interference levels will permit data rates sufficient to handle the data rate requirements below 10,000 feet. In addition, under AirCell's proposals, service providers will have the option to do a handoff of the ATG link to an appropriate terrestrial system when the aircraft is close to or on the ground, thereby providing continuous coverage without any impact to the data rates and user experience.